General or Specific? The Memory-Experience Gap for individuals diagnosed with a major depressive disorder or a social phobia diagnosis, and individuals without such diagnoses.

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Paper accepted in Journal: Memory

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Acknowledgement

This work was supported by the Swiss National Science Foundation under Grant [SNF Grant # 100014_149524/1 and PP00P1_163716/]. We thank Sara Schmid, Viktoria Zimina, Julia Fricker, Nadine Winter, Alessandra Arnold, Andreas Baur, Tamara Stotz, Marina Brueggemann, Kathrin Frehner, and Stephanie Lange for their help with the data collection.

Words Count of the manuscript: 8298

Abstract

Psychological treatment and assessment necessarily rely on patients' recall. Yet several empirical studies have documented a gap between memory and real-life experience (i.e., memory–experience gap; MeG). We investigated and compared the MeG of sadness, social anxiety, happiness, and physical activity for participants diagnosed with a major depressive disorder (MDD), a social phobia (SP), and participants without such diagnoses (CG).

The study included 118 participants diagnosed with a MDD, 47 with a SP, and 119 CG. Using event-sampling methods (ESM), participants were asked via smartphone to report their experiences throughout a week and then to recall those again retrospectively at the end of the study week.

Results indicate significant differences in the MeG with respect to the experience that was salient to them (e.g., MDD group – sadness; SP group – social anxiety; CG group – happiness). Furthermore, all groups showed a MeG for physical activity and, the results indicate significant group differences in the magnitude of the MeGs.

This study demonstrated the presence of a MeG in individuals in a MDD, SP, and CG group and in positive and negative affective experiences. Differential patterns across the samples contribute to a better understanding of this gap and its implications.

Keywords: Memory–Experience Gap, Event Sampling Methodology, Major Depressive Disorder, Social Phobia

General or Specific? The Memory-Experience Gap for individuals diagnosed with a major depressive disorder or a social phobia diagnosis, and individuals without such diagnosis.

Our memory is not a perfect representation of the past, and recalling experiences is often biased. The difference between a person's in vivo experience and retrospective evaluation of that same experience has been referred to as the memory–experience gap (MeG; Miron-Shatz, Stone, & Kahneman, 2009). Clarifying the nature and prevalence of this gap is crucial to accurately interpret retrospectively recalled clinical and scientific data. Previous studies have focused either on part of the general populations *or* on individuals with a mental diagnosis separately when assessing the MeG. But comparing these two populations is crucial to gaining more knowledge about the specificity (the MeG is only present for a distinct population) or generalizability (the MeG exists across different populations) of the MeG.

Previous research on memory biases suggest on the one hand that some memory biases permeate human cognitive processes. According to this view, human beings 'are prone to overestimate how much they understand about the world and to underestimate the role of chance in events' (p. 17, Kahneman, 2011). Therefore, one might conclude that memory biases are a general phenomenon. However, on the other hand, studies have also reported population-specific biases. For example, participants with a diagnosis of a major depressive disorder (MDD) have been shown to be more likely to falsely recall negative words during memory tests compared to participants in a control group (Joormann, Teachman, & Gotlib, 2009). Cognitive biases have furthermore been reported in individuals with symptoms of social phobia (SP), especially for threatening stimuli. During a visual-probe task, individuals diagnosed with SP showed slower reaction times when angry faces were displayed than participants in the control group (Mogg, Philippot, & Bradley, 2004), leading to a bias towards social threat cues. Furthermore, some

research suggests that some memory biases are present across all individuals (general), but are larger for specific populations (specific). For example, it has been shown that all individuals tend to better remember negative than positive events (Ganzach & Yaor, 2019; Kreitler & Kreitler, 1968). Additionally, recollection of negative affect has been shown to be influenced by negative emotional peaks (high negative emotional peaks are linked with higher retrospective recall of negative affect; Ganzach & Yaor, 2019), while the retrospective recollection of positive affect is more affected by the end affect (retrospection of positive affect is overestimated when the last affect was also positive; Ganzach & Yaor, 2019). As such in line with previous studies, one might expect that all individuals show a higher MeG for negative affect, represented by a overestimation, compared to positive affect (Ganzach & Yaor, 2019; Miron-Shatz et al., 2009). Further, some individuals – for example individuals with symptoms of depression – will have an even higher MeG for negative affect compared to others, because they report higher negative daily affect (higher negative peaks) and more unpleasant events (Bylsma, Taylor-clift, & Rottenberg, 2011). However, to our knowledge the MeG for different experiences has not been compared for individuals with depression or anxiety and individuals without a mood or anxiety disorder, therefore it remains unclear whether indeed the MeG (i.e. the end product of these memory biases) itself is general or observable only in some individuals with certain memories or both.

Previous studies have tested the presence of a MeG for patients using diagnostic-specific stimuli, such as pain, panic attacks, binge episodes in eating disorders, tobacco consummation and obsessive-compulsive symptomatology, and most, but not all, found a MeG. For example, individuals meeting the threshold or subthreshold for an eating disorder and individuals with a diagnosis of a chronic pain disorder retrospectively recalled more pain and binge episodes than

were collected through event-contingent and time-prompt electronic diaries (Stein & Corte, 2003; Stone, Broderick, Shiffman, & Schwartz, 2004). Patients with panic disorders and agoraphobia also retrospectively overestimated panic frequency before treatment when compared to a self-monitored paper and pencil diaries (De Beurs, Lange, & Van Dyck, 1992; Margraf, Taylor, Ehlers, Roth, & Agras, 1987). Another study by Shiffman et al., (1997) identified a MeG (overestimation) for tobacco consumption in individuals smoking who intended to quit smoking using an event sampling methodology (ESM) with a palm size computer. On average, participants in this study retrospectively overestimated the number of cigarettes they consumed during smoking lapses as well as their negative effect, suggesting that the MeG applies for at least this observable experience and population. Interestingly, one study examining the MeG for patients with obsessive-compulsive disorder could not confirm a MeG (Gloster et al., 2008). Participants showed an accurate recollection of diagnostically specific experiences in this population. This accuracy may be due to the specific characteristics of the obsessive-compulsive disorder population or because this study uses time-stamped via smartphone assessed event-sampling methodology (ESM).

Other studies also suggest the presence of a MeG in participants not selected for mental disorders. A study by Tadic, Braam, VanVliet, and Veenhoven, (2013), for example, showed an MeG by presenting a discrepancy between the retrospective recall of happiness and the in vivo reported level of happiness in adolescents from the general population. The MeG thus consisted in a retrospective overestimation of the levels of happiness. Miron-Shatz and collegues (2009) provided another example of the MeG for happiness. In this study, female participants retrospectively felt happier and friendlier compared to their levels of happiness reported within specific experiences. The study by Miron-Shatz and collegues (2009) furthermore underlined the

presence of a MeG for feelings of anger and tension (referred to as unpleasant experiences). Using the day-reconstruction method, experiences of anger and tension were retrospectively overestimated by the participants, and the MeG was found to be larger for unpleasant than pleasant experiences.

Summarizing, studies have found a MeG, usually in the direction of overestimation, for symptom-specific experiences for patients with diagnosis and more generalized emotions for individuals of the general population or individuals not selected for mental disorders. However, as studies have not directly compared the MeG in individuals with and without diagnosis with the same stimuli, the question of whether a MeG is a general phenomenon, a specific phenomenon, or a combination thereof remains unclear. Due to overall human memory biases, one might expect that a MeG exits for all experiences and all populations. However, due to population-specific biases and population characteristics, (e.g. slower reaction times when angry faces are displayed in individuals with a diagnosis of SP), the magnitude of MeG could potentially be larger for some specific experiences in specific populations. Furthermore, most studies that have reported a MeG used paper-and-pencil diaries without a time-stamp function. Participants have been shown to miss-schedule the recording of their experiences within a paper diaries, as they allow the participants to complete the assessments at a later time (Davidson, Anestis, & Gutierrez, 2017). Overall, using retrospectively assessed methods is prone to recollection biases itself (Trull & Ebner-Priemer, 2013), because individuals are asked to recall a past event, and are not asked to report what happened in their close present. Some have used the day reconstruction method to reduce error and bias. Day reconstruction measure has been shown to indeed reproduce valid information of daily affect (Dockray et al., 2010). However, assessing the MeG using ESM and specifically via cellular phones or smartphones has previously been

recommended (Gloster et al., 2008; Miron-Shatz et al., 2009; Trull & Ebner-Priemer, 2013), as the assessment is even closer to the real time of the experience. The use of smartphone in the general population is increasing, it includes the advantages of palm size computer and permits, with the technological advances (sending messages, apps) a more flexible way of collecting data (Davidson et al., 2017).

This study extends the literature on the MeG by examining this gap using time-stamped ESM for individuals diagnosed with MDD or SP and for individuals without such diagnosis with respect to experiences of sadness, social anxiety, happiness, and physical activity. We hypothesized that a MeG is present in all three groups (MDD, SP, and control) for experiences of sadness, social anxiety, happiness, and physical activity (hypothesis one). We further hypothesized that participants in the control group would differ with respect to the size of the MeG from participants in the MDD and in the SP group (hypothesis two). Specifically, we expect that for sadness and social anxiety the MeG would be larger for individuals in the MDD and SP group compared to participants in the control group.

Methods

Participants

The sample consisted of 290 individuals: participants were diagnosed with either SP or MDD, or they were in the control group that had neither SP or MDD. Eight participants in the control group met criteria for a primary diagnosis of either cannabis abuse, specific phobia, panic disorder without agoraphobia, obsessive compulsive disorder or insomnia. The MDD and the SP groups had some overlap of diagnoses at lower severity levels. 31.92% of the individuals in the MDD group had a comorbid diagnosis of social phobia and 23.73% of the individuals in the SP

group had a comorbid depression diagnosis. Detailed description of co-morbidities can be viewed within supplementary material. That is, group assignment was made based on the primary diagnosis, but co-morbidity of diagnoses at a lower severity level was allowed. Our goal was to recruit a sample representative of clinical reality and therefore generalizable sample; as such allowed commodities with lower severity levels as opposed to recruiting a highly selective and clinically atypical group consisting only of mono-diagnostic groups. It was further our assumption that if this did affect the results, it was against the direction of our hypotheses because groups without comorbidity would artificially inflate differences between the groups.

Patients were recruited from treatment centers (university clinics and cooperating local practitioners) in Switzerland and Germany. Participants in the control group were recruited through local advertisements (flyers were distributed in local stores and the study was advertise via an online blackboard). Participation for the study occurred independent of therapy. Six participants reported on less than 50% of the ESM assessments and where therefore excluded from the study. The final sample size consisted of 118 participants in the MDD, 47 in the SP, and 119 in the control group. The sample was 67% female. The average age was 32 years (*SD* = 11.52, range 18–63). The three groups were matched for age and sex. In order to guarantee that the three groups had similar mean age and gender distribution, we specified the age and sex of participants to be recruited in the control group to match the general age brackets of participants in the MDD and SP groups. Overall, participants responded to 92% of the prompted ESM assessments, for a total of $N = 10979$ assessments. Of these, 51 were only partially completed. Leaving, $N = 10928$ assessments (92%) that were fully completed. Further demographic information such as employment status, years of education and number of diagnosis can be

viewed in table 1. The sample size is adequately powered for the hypothesis (Gloster et al., 2017) and was specifically designed to test the generalizability.

[Table 1 near here]

Procedure

The data is part of a larger longitudinal study and was approved by the Ethikkommission Nordwest- und Zentralschweiz (EKNZ – 236-12). Detailed descriptions of the study design and procedure are presented elsewhere (Gloster et al., 2017). At baseline, participants gave informed consent, answered demographic questions, filled out questionnaires on symptoms, emotion regulation, and well-being, and completed a diagnostic interview. To assure the reliability of the diagnoses, each patients' diagnoses was discussed with a senior clinical psychologist. Depending on the diagnostic status of each participant (DSM-IV MDD diagnosis, DSM-IV SP diagnosis or no DSM-IV diagnosis for MDD or SP), was then assigned to one of the three study groups: MDD, SP, or control. One week after the baseline assessment, participants received an ESM training, that is, they were given the smartphone they were going to use for the next 7 days and were trained how to fill out questionnaires on it. Between the ESM training (day 8) and the last appointment (day 15), participants completed questionnaires on the smartphone contingent on an audible signal every 3 hours during each day (six prompts during each day). Items for sadness, social anxiety, happiness, and physical activity were asked 5 times a day. The last questionnaire was assessed shortly before bed-time of each participant (e.g. 8 a.m., 11 a.m., 2 p.m., 5 p.m., 8 p.m., and 11 p.m.). The first morning questionnaire only included few items to reduce burden of the participant. The participants returned the device at the last appointment. During the post assessment, participants were asked to recall experiences they had recorded on the smartphone during the previous seven days. The participants also filled out further questionnaires. All

assessments were conducted in German.

Assessments

Diagnostic

At baseline, trained PhD students and master's students performed the Axis I of the Structured Clinical Interview (SCID-I) to determine the diagnostic status of each participant.

The SCID-I is a semi-structured clinical interview that is designed to determine DSM-IV conform diagnoses (Wittchen, Wunderlich, Gruschwitz, & Zaudig, 1997). The SCID-I is a reliable and valid instrument for assessing Axis I diagnosis (First & Gibbon, 2004). Lobbestael, Leurgans, and Arntz (2011) show moderate to excellent inter-rater with a mean Kappa of 0.71.

Furthermore, participants were asked at baseline to fill out the Beck Depressive Inventory (BDI-II; Hautzinger, Keller, & Kühner, 2009), the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998), the Perceived Stress Scale (PSS; Cohen & Janicki-Deverts, 2012) and the short form of the Mental Health Continuum (MHC-SF; Lamers, Westerhof, Bohlmeijer, Klooster, & Keyes, 2010).

The BDI-II (Hautzinger et al., 2009) contains 21 items designed to assess depressive symptomatology and suicidal ideation over the preceding two weeks. One-week test–retest reliability for the BDI-II is .93 and internal consistency is .92 among outpatients (Beck, Steer, & Brown, 1996).

The 20 items version of the SIAS (Mattick & Clarke, 1998) was used to measure social anxiety, specifically participants reaction to situations that involve social interactions. The instrument scales from 0 "not at all" to 4 "extremely". The been shown to be a valid instrument (Brown et al., 1997).

The PSS (Cohen & Janicki-Deverts, 2012) is most widely used to measure stress scale from 0 “never” to 4 “very often”. High scores on the items represent high level of perceived stress. The instrument show good validity and reliability. We used the 10 items version. The PSS shows high reliability and validity (Roberti, Harrington, & Storch, 2006).

Finally, the MHC-SF (Lamers et al., 2010) is a reliable (Keyes, 2005) and valid (Keyes, 2006; Lamers et al., 2010) measurement for well-being. Overall, 14 items measure emotional well-being (happy, interested in life, and satisfied), psychological well-being (self-acceptance, environmental mastery, positive relations with others, personal growth, autonomy, purpose in life) and social well-being (social contribution, social integration, social actualization, social acceptance, social coherence). Scaling go from 0 “never” to 5 “every day”. High score represents high level of well-being.

Memory–experience gap

To measure the MeG, we assessed the level of sadness, social anxiety, happiness, and physical activity of each participant several times during the ESM week and once again during the post assessment. We chose to measure the experiences of sadness and social anxiety because they represent experiences that are characteristic for individuals with a MDD and a SP diagnosis. We further chose the experience of happiness as a specific affect and the experience of physical activity as an observable behavior since those experiences are present across all individuals. The items asking for the level of, sadness, social anxiety, happiness, and physical activity originated from previous ESM studies (Brown, Strauman, Barrantes-Vidal, Silvia, & Kwapil, 2011; Gloster et al., 2008; Kashdan & Steger, 2006), validated questionnaires (Beck et al., 1996; Bundesamt für Statistik, 2013), and self-developed items. Items were modified to query for sadness, social anxiety, happiness and physical activity since the last assessment (ESM items) or were queried

for the previous week (retrospective items). Based on the BDI-II (Hautzinger et al., 2009) and previous ESM studies sadness (Brown et al., 2011) was assessed with the wording "did you feel sad". Based on a previous ESM study from (Kashdan & Steger, 2006) social anxiety was assessed with the wording "were you worried about what people think about you?". The item happiness was adapted from a previous study from Brown and colleagues (2011). The item was formulated; "were you happy?". Finally, physical activity was adapted by a previous publication from a swiss health survey (Bundesamt für Statistik, 2013) with the wording "engaged in a physical activity leading to sweating for at least 30 minutes?". The items sadness, social anxiety and happiness ranged from 0 "never" to 100 "always", and the item physical activity was dichotomous "yes"/ "no" for the ESM item and from 0-7 days for the retrospective item. Specifically, ESM items began with the words: 'Since the last beep, what percentage of time did you . . .'; whereas retrospective items (after the ESM week) began with the words: 'On average during the last 7 days, what percentage of time did you . . .' (table 2).

[Table 2 near here]

Statistical Analysis

All analyses were conducted using the statistical program R, version 3.3.2 (2016/10/31). To analyze our two hypotheses, linear mixed models were conducted, which are well suited for repeated assessment measurements with interdependent observations of data nested within individuals. The outcome was the respective MeG, which was obtained by subtracting the repeatedly assessed and hence time-varying ESM based characteristics from the retrospectively assessed characteristics, which was assessed once. Thus, the resulting difference score was also time-varying an estimate of the experienced MeG at each point in time.

For hypothesis one, we ran a separate model for each study group and outcome. The model contained only a fixed and a random intercept, but no predictors since we were interested deviations of the outcome from 0. The fixed intercept thereby tested the presence of a MeG for a specific study group. To test whether the magnitude of the MeGs differed among the three study groups (hypothesis 2) we combined the data of the three study groups and added study group as a fixed effect to the model used for hypothesis one. The analysis of the outcome physical activity differs from the other tested experiences, in that participants were retrospectively asked to report the number of days in a week that they exercised while in the ESM assessment participants were asked whether they had engaged in a physical activity. Therefore, this outcome was only available on a weekly basis (and not several times a day as for the other outcomes) and varied between 0 and 7. We consequently used a paired t-test to analyze this outcome with the two methods of assessing the weekly number of physical activity (via ESM or retrospectively) as factor.

Results

During the ESM assessment (in vivo experience), across all participants reported that they were sad, socially anxious and happy, 28%, 27% and 50% of the time, respectively. They were further engaged in physical activity on 2.77 days during the ESM week (self-reported via ESM). Table 3 gives further information on the characteristics of the three groups, separately for these smartphone and retrospective assessments.

[Table 3 near here]

Hypothesis 1

Figure 1 and figure 2 graphically depict the results of the first hypothesis. That is, they show the presence of a MeG for participants in the MDD, SP, and control groups with respect to experiences of sadness, social anxiety, happiness, and physical activity.

Sadness and Social anxiety

First, linear mixed models showed that participants in the control group significantly overestimated their levels of sadness (by 2.55, $p < 0.01$, 95% CI [0.65-4.45]) when recalling them retrospectively in comparison to measuring it with ESM. With respect to social anxiety, participants in the control group did not show any indication of a MeG (0.19 difference between the retrospective recall and ESM, $p = 0.81$, 95 % CI [-1.43 – 1.81]).).

Participants in the MDD group strongly overestimated both their levels of sadness (by 12.52, $p < 0.001$, 95% CI [9.60– 15.44]), and their level of social anxiety (by 11.58, $p < 0.001$, 95 % CI [8.45–14.71]) when recalling them retrospectively. Similarly, participants in the SP group also overestimated both their levels of sadness (by 6.05, $p < 0.001$, 95% CI [2.53 – 9.58]), and even more so of social anxiety (by 13.31, $p < 0.001$, 95% CI [10.59–16.44]) when recalling them retrospectively.

Happiness

Participants in the control group overestimated their levels of happiness by 6.55 when recalling it retrospectively in comparison to measuring it in vivo ($p < 0.001$, 95% CI [4.55–8.55]). In contrast, participants in the MDD more or less *accurately* recalled their happiness (difference 1.10 compared to levels of happiness measured in vivo, $p = 0.31$, 95% CI [-1.02–3.22]). Similar to participants in the control group, though to a lesser degree, participants in the SP group overestimated their levels of happiness by 4.50 when recalling it retrospectively in comparison to their in vivo reports ($p = 0.01$, 95% CI [0.98–8.02]).

Physical Activity

Regarding physical activity, participants in all three groups retrospectively underestimated the number of days they had engaged in physical activity (figure 2). Participants in the control group underestimated the days they had engaged in a physical activity by -0.34 (p = 0.013, 95% CI [-0.77–-0.21]), as well as participants in the MDD group by -0.27 (p = 0.03, 95% CI [-0.61– -0.12]), and participants in the SP group by -0.37 (p = 0.03, 95% CI [-0.84 – -0.16]).

Hypothesis 2

The size of the MeG differed among participants in the control group and participants in the MDD group across most experienced characteristics. The MeG (represented by a overestimation) was hereby significantly higher for sadness (by 10.06, $p < 0.001$, 95% CI [6.43-13.30])) and social anxiety (by 11.33, $p < 0.001$, 95% CI [7.86– 14.91]) in participants in the MDD group and significantly lower for participants in the MDD group for happiness (by -5.58, $p < 0.001$, 95% CI [-8.40 – -2.49]). Participants in the control group and participants in the MDD group did not differ in their MeG for the experience of physical activity.

The MeG (represented by a overestimation) for the experience of social anxiety also differed significantly between participants in the control group and participants in the SP group (by 13.12, $p < 0.001$, 95% CI [8.42–17.84]), with a higher gap for participants in the SP group. However, for all other experienced characteristics (sadness, happiness and physical activity) participants in the control group and participants in the SP group showed no differences in their MeGs.

[Figure 1 and 2 near here]

Discussion

Discussion of the results

This study examined whether participants' experiences and memories (MeG) differed both within and between participants in an MDD, participants in an SP, and participants in a control group. Overall, our findings suggest that the MeG (usually an overestimation) exists across participants in the MDD, participants in the SP, and participants in the control group alike, but that the size of the recall bias (how much is overestimated/underestimated) depends on the study groups.

Our first hypothesis—that a MeG exists for participants in the MDD, SP, and control groups—was generally confirmed for the internal experiences of sadness, social anxiety, happiness, as well as the discreet experience of physical activity. We found a MeG for symptom specific experiences, specifically, an overestimation of sadness and social anxiety in individuals with symptoms of MDD or SP, respectively. Each group showed the largest overestimation with respect to the experience that is salient to that group – interestingly, this effect was not limited to negative affect, but encompasses positive affect (in participants in the control group), too. These results are in line with previous studies that have shown that patients with a diagnosis of chronic pain and patients with a diagnosis of eating disorders overestimated the intensity and frequency of their symptom specific experiences (Stein & Corte, 2003; Stone et al., 2004). Furthermore, this result is in line with previous studies that have shown a MeG for happiness in women (Miron-Shatz et al., 2009; Tadic et al., 2013). The different amplitudes of MeGs between participants with a MDD or SP diagnosis, and without such diagnosis have previously not been described and extend our knowledge on the MeG, and suggest that the MeG occurs in stimuli that are most salient within each person's idiographic profile.

Interestingly, participants in the MDD group overestimated with a high magnitude all assessed symptom specific experiences (sadness and social anxiety), whereas participants in the

SP group also overestimated both symptom specific experiences but with a clearly higher magnitude for the experience of social anxiety. Additionally, only participants in the control and in the SP group overestimated happiness. In contrast participants in the MDD group accurately recalled that they had been happy approximately a third of the time – and this was lower in absolute levels than both participants in the SP and participants in the control group. The present results are congruent with the tripartite model of anxiety and depression (Clark & Watson, 1991). The model described shared components between depression and anxiety that explains the high co-morbidities between those disorders. Moreover, the model also refers to disorder specific components (such as hyperarousal specific for anxiety and low positive affect specific to depression) that account for differences between the two. As such, similarities between participants diagnosed with MDD and SP diagnosis could explain the general tendency of both to overestimate sadness and social anxiety and the differences between both for the experience of happiness.

We also found a MeG for the experience of physical activity over all study groups. All groups significantly underestimated the number of days they had engaged in physical activity. This result adds to the literature because, to the best of our knowledge, the MeG for physical activity has not yet been assessed. Nevertheless, previous studies on the MeG for other observable experiences, such as tobacco consumption, have also shown a MeG (Shiffman et al., 1997).

Using this methodology, we documented that individuals with a diagnosis of MDD or SP are off by between 6 and 13 percent when they retrospectively estimate the identical information. Importantly, this estimate is probably a best-case scenario because the participants were prompted every three hours to think about these experiences. As such, these rates likely

underestimate the actual MeG present when questionnaires or interviews are used without prior prompting.

Our second hypothesis, which stated that participants in the MDD, the SP and the Control group would differ from each other in the size of their MeG, was confirmed. The results indicate significant group differences in the magnitude of the different MeGs. The MeG (represented by a overestimation) for the experience of sadness was larger for participants in the MDD group compared to participants in the control group. In contrast, participants in the SP and participants in the Control group did not significantly differ from each other with respect to sadness. But when the MeG was analyzed for social anxiety, the MDD and SP groups had both higher MeGs (represented by a overestimation) than the participants in the control group. An opposite result could be shown for the MeG for the experience of happiness and physical activity, as such as the MeG (represented by a overestimation for happiness and a underestimation for physical activity) was larger for participants in the control group compared to participants in the MDD group. These results of the second hypothesis are in line with the previous findings from Miron-Shatz and colleges (2009), and Ganzach and Yaor (2019). The MeG was indeed larger for negative affect compared to positive affect, this however was specific to individuals with depression or social anxiety. Which speaks for the fact that individuals with a diagnosis of depression or SP have specific characteristics or experiences that further increase a MeG for negative experiences (e.g. specific population biases or higher negative peaks). Furthermore, it seems that the MeG is indeed a general phenomenon, as all our study groups reported discrepancies, but that the presence of the gap and the size of it is related to specific populations (MDD group, SP group, or control group).

Theoretical contributions

To our knowledge this study is the first to show population specific differences in the MeG. A consistent and overall theme of our results is the tendency of participants in the control group to report a higher magnitude in the MeG (reported as an overestimation) in happiness compared to participants in the MDD and SP group. The MeG in participants with a MDD or SP diagnoses was nearly the opposite pattern of the MeG in participants in the control group. It has previously been claimed that individuals without a diagnosis of depression have cognitive biases that enable them to see themselves and their environment in a positive light (Alloy & Abramson, 1979). This self-attribution bias (e.g., making internal attributions for successes and external attributions for failures; Alloy & Abramson, 1981) has been described as an adaptive strategy that maintains a sense of well-being (Ackermann & DeRubeis, 1991). Overestimating happiness could therefore also have a protective function for mental disorders. Overestimating sadness and social anxiety could hypothetically be a result of diagnostically specific attentional biases toward mood-congruent experiences in individuals with symptoms of depression (Mathews & MacLeod, 2005) and toward threatening experiences in individuals with symptoms of social anxiety (Mogg et al., 2004). A crucial question that further studies need to address is whether these cognitive biases explain the different size of the MeG and, further, if an overestimation of happiness is a protective factor for the development of mental disorders whereas an overestimation of diagnostically specific experiences is a risk factor for the development and maintenance of mental disorder, in addition to other cognitive and behavioral factors.

Practical Implication

These findings are of use for clinical practice and research. Next to other validated assessment and treatment components, researchers and clinicians should consider adding ESM more often in therapy and research since our results clearly show that information assessed

through retrospective recall is biased. As such clinicians could for example show patients the discrepancy between their weekly assessed symptoms, and their retrospectively remembered symptoms. As a result, this could promote in therapy cognitive reconstruction and increase the patient's motivation for improving their daily mindfulness to reduce the memory-experience gap. Methods of cognitive reconstruction and mindfulness have previously been shown to reduce symptoms and increase individual's well-being (Clark & Beck, 2010; Hofmann, Sawyer, Witt, & Oh, 2010). Another practical implication could be to strengthen positive view as a potential protective factor of psychopathologies. Previous findings show that more happiness is related to less psychopathological symptoms (Garaigordobil, 2015), and is related to more success in several life domains, such as work, relationships and physical health (Lyubomirsky, King, & Diener, 2005). Hypothetically, it is not only the level of happiness that is a protective factor against psychopathologies, but also the presence of a memory-experience gap of happiness (specifically the overestimation of happiness) that acts as a protective factor. Future studies should therefore include the memory-experience gap of happiness, next to other well-known protective factors (e.g. coping strategies, social support; Roohafza et al., 2014)), as a predictor for psychopathologies to test this hypothesis.

Limitations

There are some limitations to this study that should be mentioned. First, although ESM is designed to collect real-time data, we used it to measure retrospectively recollected experiences from the previous 3 hours. Nevertheless, ESM permits data collection in vivo that is close to real time and thus drastically reduces the factors that make later recall biased. Furthermore, answering questions several times a day on a smartphone could pose a reactivity threat if it leads to participants recalling their weekly experiences better. If this is the case, we assume that if

anything, this resulted in an underestimation of the MeG in this study. Second, further variable could also confound with our results and explain a MeG.

Conclusion

These limitations notwithstanding, concluding this study extends the literature on ESM and the MeG by showing initial evidence of the memory-experience gap as a function of the interaction between diagnosis and targeted experience. We suggest that the differences of the MeG in patients with a diagnosis of MDD or SP and individuals without such diagnosis could contribute to the explanation of differences in the status of their psychological health. A MeG in happiness and positive experiences could contribute to psychological health, and a MeG in diagnostically specific experiences could contribute to the maintenance of symptoms. Further research is needed to test the function of the MeG as an amplifier for health or psychopathologies.

Disclosure statement

The authors reported no potential conflict of interest.

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Tables

Table 1

Demographic information of the sample

	Control	*MDD*	*SP*
Years of education in %			
8-10	*12.0*	*21.1*	*9.3*
11-13	*53.0*	*51.4*	*67.4*
14+	*35.0*	*27.5*	*23.3*
Employment status			
% Employed	*57.1*	*52.5*	*38.3*
% Unemployed	*39.5*	*46.6*	*61.7*
Number of diagnoses in %			
0	*90.8*	*0.0*	*0.0*
1	*6.7*	*45.8*	*44.7*
2	*1.7*	*29.7*	*27.6*
3+	*0.8*	*24.6*	*27.7*
BDI Mean and (SD)			
	27.0 (8.2)	17.0 (11.7)	3.0 (7.1)
SIAS Mean and (SD)			
	31.0 (14.4)	44.0 (12.5)	10.0 (7.3)
PSS *Mean and (SD)*			
	27.0 (5.3)	25.0 (6.0)	13.0 (7.2)

MHC-E *Mean and (SD)*			
	1.67 (0.96)	2.67 (1.12)	4.00 (0.92)
MHC-S *Mean and (SD)*			
	1.20 (0.94)	1.40 (0.96)	2.60 (1.14)
MHC- P *Mean and (SD)*			
	1.75 (0.98)	2.17 (1.19)	3.50 (0.96)

Note. Control = participants without a diagnosis of a major depressive disorder or social phobia, MDD = participants diagnosed with a major depressive disorder, SP = participants diagnosed with a social phobia; BDI‐II = Beck Depression Inventory; SIAS = Social Interaction Anxiety Scale; PSS = Perceived Stress Scale; MHC‐E, −S, −P = Mental Health Continuum – Emotional, Social, and Psychological subscales, SD = standard deviation.

Table 2

Formulation of the event sampling method and retrospective items

Type of experience	ESM items	Retrospective items	Range
Sadness	Since the last beep, what percentage of the time did you feel sad?	On average during the last 7 days, what percentage of the time did you feel sad?	ESM & retrospective items: from 0 (never) to 100 always
Social anxiety	Since the last beep, what percentages of the time were you worried about what people think about you?	On average during the last 7 days, what percentage of the time were you worried about what people think about you?	ESM & retrospective items: from 0 (never) to 100 always
Happiness	Since the last beep, what percentage of the time were you happy?	On average during the last 7 days, what percentage of the time were you happy?	ESM & retrospective items: from 0 (never) to 100 always

Physical activity	Since the last beep, have you engaged in a physical activity leading to sweating for at least 30 minutes?	How many days did you pursue a physical activity leading to sweating for at least 30 minutes?	ESM item: dichotomy scaling (Yes/No), Retrospective items: from 0 to 7 days

Note. ESM = items assessed via an event sampling method (smartphone).

Table 3

Means and Standard Deviations of sadness, social anxiety and happiness and the Sum of the days individuals have engaged in a physical activity assessed through event sampling methods and retrospectively.

		ESM	Retrospective recall
Sadness			
(Range: 0-100)	Control	9.95 (13.11)	12.24 (16.50)
	MDD	31.29 (20.37)	43.90 (27.96)
	SP	22.64 (16.65)	28.02 (19.20)
Social anxiety			
(Range: 0-100)	Control	8.68 (9.45)	8.74 (11.31)
	MDD	28.05 (19.82)	39.61 (29.44)
	SP	28.46 (18.53)	41.12 (22.25)
Happiness			
(Range: 0-100)	Control	63.73 (23.95)	70.21 (26.43)
	MDD	31.90 (19.48)	32.69 (22.85)
	SP	35.11 (20.81)	39.54 (24.14)
Physical activity			
(Range: 0-7 days)	Control	3.67 (2.22)	3.25 (2.16)
	MDD	2.69 (2.22)	2.33 (2.19)
	SP	3.00 (2.20)	2.63 (2.10)

Note. This table represents retrospective values and values assessed through an event sampling method (smartphone) for each group and each experience. The differences between retrospective recall and event sampling method represent approximately the memory-experience gap (MeG) calculated via GLLM. MeG scores can differ in the GLLM model, because GLLM model represent calculate estimated values. ESM = values assessed via an event

sampling method (smartphone), Control = participants without a diagnosis of a major depressive disorder or social phobia, MDD = participants diagnosed with a major depressive disorder, SP = participants diagnosed with a social phobia.

Figures

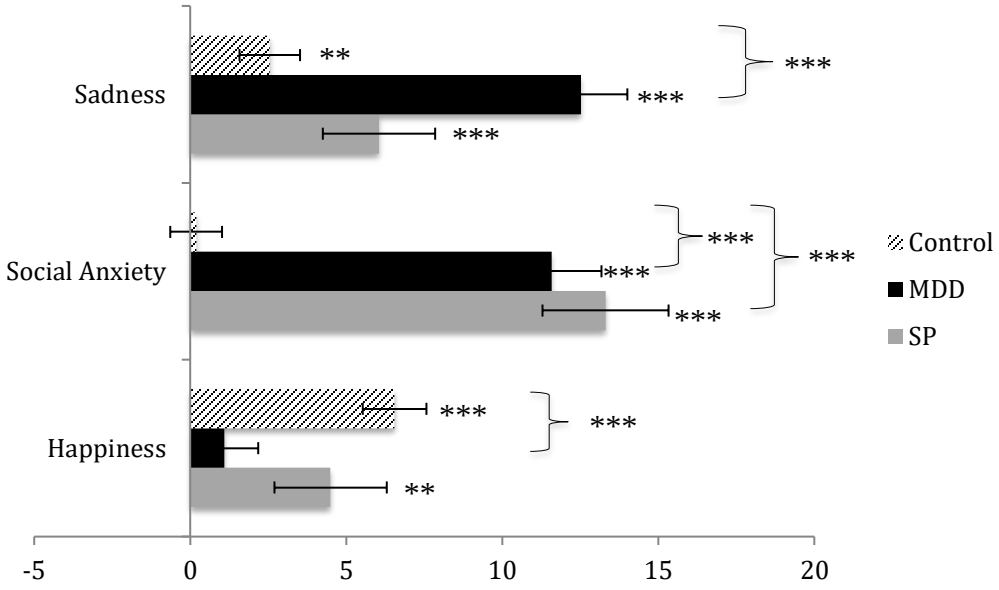

Figure. 1 Group-specific memory-experience gap (MeG) for the experiences of happiness, social anxiety, and sadness. A MeG of 0 represents an accurate retrospective recall of the experience. Negative scores represent retrospective underestimations, and positive scores retrospective overestimations. Significant MeGs as well as significant between-group comparisons are coded in this figure on a p level of *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$. Control = participants without a diagnosis of a major depressive disorder or social phobia, MDD = participants diagnosed with a major depressive disorder, SP = participants diagnosed with a social phobia.

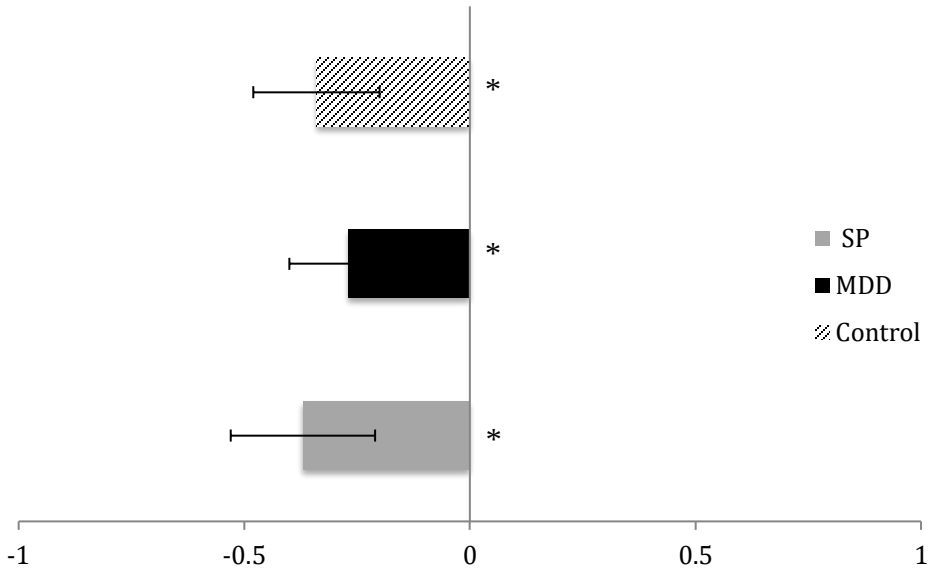

Figure. 2 Group-specific MeG for physical activity. A memory-experience gap (MeG) of 0 represents an accurate retrospective recall. Significant negative MeG scores represent retrospective underestimations of the number of days of physical activity. Significant MeGs are coded in this figure on a p level of *** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$. No significant between-group comparisons were shown for the experience of physical activity. Control = participants without a diagnosis of a major depressive disorder or social phobia, MDD = participants diagnosed with a major depressive disorder, SP = participants diagnosed with a social phobia.

SUPPLEMENTARY MATERIAL

Table

Description of co-morbidities

		Control (N = 119)		MDD (N =118)		SP (N = 47)	
ICD-10 code	**Description**	**N**	**%**	**N**	**%**	**N**	**%**
F10.1	Alcohol abuse	0	0	3	2.54	1	2.13
F12.1	Cannabis abuse	0	0	1	0.85	0	0
F30	Manic episode	0	0	0	0	0	0
F30.9	Manic episode, unspecified	0	0	1	0.85	0	0
F32	Major depressive disorder, single episode	0	0	0	0	13	27.66
F33	Major depressive disorder, recurrent	0	0	0	0	2	4.26
F34.1	Dysthymic disorder	0	0	6	5.09	2	4.26
F40.00	Agoraphobia, unspecified	0	0	5	4.24	2	4.26
F40.01	Agoraphobia with panic disorder	1	0.84	3	2.54	2	4.26
F40.1	Social phobias	0	0	28	23.73	0	0
F40.2	Specific (isolated) phobias	1	0.84	9	7.63	6	12.77
F41.0	Panic disorder without agoraphobia	1	0.84	6	5.09	1	2.13
F41.1	Generalized anxiety disorder	0	0	22	18.64	7	14.89
F41.9	Anxiety disorder, unspecified	0	0	2	1.70	0	0
F42.0	Predominantly obsessive compulsive cognition	0	0	0	0	0	0
F42.1	Predominantly obsessive compulsive behavior	1	0.84	4	3.39	1	2.13
F42.2	Obsessive compulsive cognition and behavior	2	1.68	2	1.70	1	2.13
F42.8	Obsessive compulsive disorder, unspecified	0	0	0	0	0	0
F43.1	Post-traumatic stress disorder (PTSD)	0	0	0	0	2	4.26
F43.2	Adjustment disorders	0	0	1	0.85	0	0

F45.2	Hypochondriacal disorders	0	0	0	0	0	0
F50.0	Anorexia nervosa	0	0	0	0	0	0
F50.1	Atypical anorexia nervosa	0	0	0	0	1	2.13
F50.2	Bulimia nervosa	0	0	4	3.39	3	6.38
F50.8	Other eating disorders	0	0	3	2.54	0	0
F50.9	Eating disorder, unspecified	0	0	0	0	1	2.13
F51.0	Insomnia not due to a substance or known physiological condition	0	0	1	0.85	0	0

Note. Control = participants without a diagnosis of a major depressive disorder or social phobia, MDD = participants diagnosed with a primary major depressive disorder, SP = participants diagnosed with a primary social phobia, % = percent of the participants for each group having this specific co-morbid diagnosis